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Specification

1. Title of the Invention

Control Device for Self-Running Type Work Machine

2. Scope of Claims for a Patent

1) A control device for a self-running type work machine including a running driving mechanism driven through a torque converter connected to an output shaft of a prime mover, and a hydraulic pump driven by the prime mover, the control device comprising:

detecting means for detecting combined stall; and

rotational speed control means for reducing the engine speed of the prime mover at the time of detection of the combined stall.

2) The control device for a self-running type work machine according to claim 1, comprising a switch for selecting a mode in which the number of rotation of the prime mover is automatically reduced at the time of detecting the combined stall.

3. Detailed Description of the Invention

A. Industrial Field

This invention relates to a control device for a self-running type work machine in which it is requested that an output torque of a prime mover be distributed into a front force for excavation or the like and a running force under a well-balanced state, as is the case with a wheel loader or the like.

B. Prior Art

Fig. 7 is an entire schematic view showing one example of a wheel loader representing a self-running type work machine. This wheel loader 1 includes an engine 2, a torque converter 3, a transmission 4, propeller shafts 5, 6 and axles 7, 8. A drive torque for running is transmitted to tires 9, 10 through these components. Further, the wheel loader 1 includes a loader front 11 for performing excavation, loading works and the like, and hydraulic cylinders 12, 13 for driving the loader front 11. These hydraulic cylinders are driven by a hydraulic pump 14 provided at a power taking-out part of the transmission 4, for example..

In general, an operation of the wheel loader is carried out by a so-called combined operation of a running operation, excavation and the like. Accordingly, it is important in view of its performance how to distribute an output horsepower of the engine into a running operation and a front work. In particular, a case in which the

torque converter is under a stall condition and the loader front hydraulic circuit is under a relief state is called combined stall. This state is the most severe in load condition for the engine. Therefore, the problem with this case is how to distribute an output torque of the engine into a loader front side and a running side.

This point will be subsequently described in detail as follows.

Fig. 3 indicates an engine torque curve ET (ETH) and an absorbing torque curve TT at the time of torque converter stall. At the time of combined stall, the engine torque curve moves from a solid line ET curve to a broken line ETH curve lower by a pump absorption torque Tb in a downward parallel motion as shown in Fig. 3. Then, a point B at which the torque curve ETH shown by this broken line intersects the absorption torque curve TT of the torque converter is a so-called matching point between the engine and the torque converter, and a torque Tb' is a drive torque for running. At this time, the engine speed is decreased to Nb. In this way, when specifications of the engine, pump and torque converter are set, only one point of the aforesaid matching point B is determined.

Next, referring to Figs. 4 and 5, a lifting force and a traction force will be described.

Fig. 4 is a graph showing a matching point between a

lifting force and a traction force at the time of combined stall. Fig. 5 is a force diagram of a lifting force and a transition force at the extremity end of a bucket. In this case, since a part of a thrust force of the lift cylinder 13 generating the lifting force is cancelled with a reaction force of the traction force at the time of combined stall, as the traction force is increased, the lifting force is reduced. Accordingly, in the case where the traction force is too large (Fig. 5(b)), since the lifting force becomes relatively low, a load is hardly applied to the tires and the tires easily slip. In turn, when the lifting force is relatively too high, the retraction force is insufficient and the force diagram directs upward as shown in Fig. 5(c). That is, so-called insertion characteristic is deteriorated and the lifting arm lifts up before a load is completely loaded into a bucket. In both cases, its working efficiency is deteriorated.

C. Problems to be Solved by the Invention

In view of the above, an engine output (engine speed) is controlled through adjustment of a treading amount of an accelerator pedal in response to the content of work, thereby increasing or decreasing a retraction force (a torque converter absorbing torque) and at the same time the work lever is controlled to select the most-

suitable matching point.

Due to this fact, such a simultaneous operation as described above requires higher skills, and is not carried out with ease even by a well-trained operator and its longer hour operation disadvantageously will produce the operator's fatigue to deteriorate working efficiency.

It is an object of this invention to provide a control device for a self-running type work machine capable of temporarily decreasing a traction force at the time of combined stall to increase a lifting force.

D. Means for Solving the Problem

Referring to Fig. 1 indicating one embodiment of this invention, this invention is applied to a control device for a self-running work machine comprising a running drive mechanism 4 driven through a torque converter 3 connected to the output shaft of the prime mover 2 and a hydraulic pump 14 driven by the prime mover 2.

The aforesaid object is accomplished by providing detector means 35, 36 for detecting the combined stall, and rotational speed control means 25, 26 and 27 for reducing the engine speed of the prime mover 2 at the time of detecting the combined stall.

E. Effect

When the combined stall is detected, the engine speed of the prime mover is reduced and a running torque is

reduced. As a result, as shown in Fig. 4 and Fig. 5, a large lifting force can be obtained by a reduced amount of traction force.

Further, it should be noted that although figures according to the preferred embodiment have been used for easy understanding of this invention in the aforementioned items D and E which describe about the configuration of this invention, these figures do not restrict this invention to the embodiment.

F. Embodiment

Referring now to Fig. 1, one embodiment of this invention will be described. The same parts as those in Fig. 7 are indicated by like reference numerals.

Reference numeral 21 denotes a governor for controlling the engine speed of the engine 2. A lever 21a of the governor is connected to an accelerator pedal 24 by a flexible cable 22 through a spring 23. The spring 23 may act to prevent a maximum treading amount of the accelerator pedal 24 from being restricted even if a rotational angle of the lever 21a is restricted by a hydraulic cylinder 25. Reference numeral 25 denotes a hydraulic cylinder for pushing the governor lever 21a to reduce the engine speed, and is connected to a hydraulic source 28 through a solenoid control valve 26 and a solenoid proportional pressure reducing valve 27. A position of the governor

lever 21a set by the accelerator pedal 24 is turned counterclockwise by extending the hydraulic cylinder 25, so that the engine speed can be reduced. The solenoid proportional pressure reducing valve 27 reduces a primary pressure in response to a signal sent from a potentiometer 29 controlled by a control circuit 31 described later and outputs it. The solenoid control valve 26 is changed over based on a signal from the control circuit 31.

The control circuit 31 is constituted by a micro-computer and the like. To the input side of the control circuit 31 are connected a mode changing-over switch 32, a selective switch 34 mounted at a knob of a lift arm operating lever 33, a rotational speed sensor 35 for detecting the rotational speed of a propeller shaft 5, a pressure sensor 36 for detecting an input side pressure of the lift arm hydraulic cylinder 12, and a limit switch 37 for detecting a height of a bucket based on an amount of the lift arm hydraulic cylinder 12. In addition, to the output side of the control circuit 31 are connected the potentiometer 29 and a solenoid part of the solenoid control valve 26.

Discharging oil of the main pump 14 drives the lift arm hydraulic cylinder 12 and the hydraulic cylinder not shown through the main control valve 17. The main control valve 17 is changed over based on a pilot pressure from a

pilot hydraulic circuit not shown.

Referring to a flowchart of Fig. 2, an operation of the control device constructed as above will be described.

When the program shown in Fig. 2 is activated, at a step S1, an output N of the rotational speed sensor 35 and an output P of the pressure sensor 36 are read in, and at a step S2, it is determined whether or not the mode changing-over switch 32 is turned on. If ON state is detected, the operation proceeds to a step S3, it is determined whether or not the selective switch 34 is turned on. If OFF state is detected, it is determined at a step S4 whether or not the rotational speed of a propeller shaft N nearly equals 0 and a pressure P nearly equals a relief pressure so as to judge whether combined stall is present. When it is determined that combined stall is present, a timer stored in the control circuit 31 is activated at a step S5, and the solenoid control valve 26 is changed over to a position B. Then, the operation proceeds to a step S6, and it is determined whether or not the selective switch 34 is turned on. If ON state is not detected, it is determined at a step S7 whether or not time counting by the timer is finished, and when it is not finished, the operation returns to a step S6, and when it is finished, the solenoid control valve 26 is changed over to a position A at a step S8.

In turn, at a step S2, when it is determined the mode changing-over switch 32 is turned OFF, the operation proceeds to a step S9 and it is determined whether or not the selective switch 34 is turned ON. If ON state is detected, at a step S10, the solenoid control valve 26 is changed over to the position B, and when the selective switch 34 is turned OFF, the operation proceeds to a step S8. That is, even if the mode changing-over switch 32 is turned OFF, the selective switch 34 is turned ON, allowing the traction force to be made low. Further, when it is determined at a step S3 that the selective switch 34 is ON state, the operation returns. That is, the selective switch 34 is turned on even under a state in which the mode changing-over switch 32 is turned on, whereby the traction reducing control at the time of combined stall can be terminated.

In accordance with such a procedure as described above, when the mode changing-over switch 32 is ON, the selective switch 34 is OFF and the combined stall is detected, the solenoid control valve 26 is changed over to a position B. With such an arrangement as above, a primary pressure is supplied to the solenoid proportional pressure reducing valve 27, from which hydraulic oil of predetermined pressure is supplied to the hydraulic cylinder 25. As a result, the governor lever 21a turned up

to a predetermined position by the accelerator pedal 24 can be turned counterclockwise to lower the engine speed, thereby reducing the traction force. Then, when the predetermined time elapses, the control valve 26 is changed over to a position A and the engine speed returns to its original value.

This state will be described in reference to a torque curve shown in Fig. 3.

As described above, under combined stall state, the engine torque is decreased by a pump absorbing torque Tb, so that the engine torque curve ET can be expressed substantially like a two-dotted line ETH. Accordingly, a matching point at the time of combined stall occupies a position of a point B and a running torque becomes Tb'. Further, when the hydraulic cylinder 25 is driven through detection of the combined stall and the engine speed is decreased by ΔN, an absorbing torque of the torque converter is decreased. Thus a matching occurs at the matching point A. At this time, the running torque (traction force) is reduced by ΔT in comparison with the case where a matching point B is set. As a result, as shown in Fig. 4 and Fig. 5, a lifting force is increased.

With such an arrangement as above, when the solenoid control valve 26 is changed over to the position "B" at the time of combined stall detection, at the time of starting

of excavation, a lifting force and a traction force are matched to each other by giving much weight to the traction force and the bucket protrudes into an item to be excavated, and when the item is to be loaded, the operation is changed over to give much weight to the lifting force, which leads to efficient work.

Fig. 6 shows a procedure in the case where a control for reducing the engine speed controlled based on time in the aforesaid embodiment is controlled under an actual driving state of the lift arm.

The same parts as those in Fig. 7 are indicated by like reference numerals and their different points will be described as follows.

Procedures from the steps S1 to S6 are the same as those described above. At a step S5, when the solenoid control valve 26 is changed over to the position B, the engine speed is decreased, and the matching point in Fig. 3 is shifted to A. Due to this fact, the running drive torque is decreased and the traction force is reduced accordingly, but the lifting force is increased. Then, the operation transfers through the step S6 and advances to the step S21 so as to judge, by a limit switch 37, whether or not the lift arm is actually lifted up. When it is lifted up, the solenoid control valve 26 is changed over to the position A at a step S8, and engine speed is returned back

to a value set by the accelerator pedal 24. When the lift arm is not lifted up, the operation proceeds from the step S21 to the step S22, and after waiting during a predetermined time. If the lift arm is lifted up during the waiting time, the operation proceeds to the step S8, and if it is not lifted up, the operation proceeds to a step S23 to control a potentiometer 29 and a secondary pressure from the solenoid proportional pressure reducing valve 27 is increased to increase an extending amount of the hydraulic cylinder 25, thereby further decreasing the engine speed and reducing the running drive torque. As a result, if the lifting force is further increased and the lift arm is driven, the operation jumps to the step S8 to recover the engine speed.

With the foregoing procedure, since the engine speed is automatically decreased until the lift arm is actually driven at the time of combined stall, an operator may exclusively concentrate on an operation of the front work lever, with the result that its workability is improved.

Further, in the case of the embodiment shown in Fig. 2 and Fig. 6, the potentiometer 29 may be adjusted according to a preference of the operator or a work condition to change a reduction amount ΔN of the engine speed. In addition, this invention can be applied to various kinds of self-running type work machine in addition

to a wheel loader.

In the constitution of the aforesaid embodiment, the engine 2 constitutes a prime mover, the transmission 4 and the propeller shafts 5, 6 constitute a running drive mechanism, the rotation speed sensor 35, the pressure sensor 36, and the control circuit 31 constitute detector means, the hydraulic cylinder 25, control valve 26, and the pressure reducing valve 27 constitute engine speed control means.

G. Effects of the Invention

In accordance with this invention, when the combined stall is detected, the engine speed of the prime mover is reduced to decrease a traction force, thereby attaining a lifting force. Therefore, even if a predetermined traction force is applied to increase insertion characteristics, the traction force is automatically reduced at the time of combined stall, in which a bucket inserts into sand and soil, to attain a desired lifting force, thereby providing a work machine improved in operability and producing worker's less amount of fatigue. In addition, provision of the selective switch may exhibit some effects of being able to select an automatic reducing control under the combined stall state according to an operator's preference and a convenience in operation of the machine is further improved.

4. Brief Description of the Drawings

Fig. 1 is an entire configuration view showing one preferred embodiment of this invention.

Fig. 2 is a flowchart showing one example of its procedure.

Fig. 3 is a diagram showing a matching between an engine torque curve and an absorbing torque curve under a torque converter stall state.

Fig. 4 is a graph showing a relation between a traction force and a lifting force.

Fig. 5 is a force diagram showing the traction force and the lifting force.

Fig. 6 is a flowchart showing another example of the procedure.

Fig. 7 is an entire schematic side elevational view showing a wheel loader.

1: Wheel loader 2: engine

3: Torque converter 11: Loader front

12: Lift arm hydraulic cylinder 14: Pump

21a: Governor lever 24: Accelerator pedal

25: Hydraulic cylinder 26: Solenoid control valve

27: Solenoid proportional pressure reducing valve

29: Potentiometer 31: Control circuit

32: Mode changing-over switch 34: Selective switch

35: Rotational speed sensor 36: Pressure sensor

37: Limit switch